CHAPTER 9

ELECTRONIC SYSTEMS MAINTENANCE

The ability of any command to carry out its assigned mission is directly related to the operational readiness of its electronic systems and equipment. It follows therefore, that electronics maintenance is of prime importance to a command.

An untimely or undetected component failure can abort the entire command mission. Therefore, it is incumbent on you as a technician, to perform preventive and corrective maintenance correctly, conscientiously, and as quickly as possible. To do this, you must develop the expertise to recognize trouble symptoms and make appropriate repairs with a minimum expenditure of manpower, money and materials. This expertise can be realized only through diligent efforts on your part and adherence to tested and proven methods.

DEFINITIONS OF MAINTENANCE

Electronic equipment maintenance can be divided into two categories: preventive maintenance, and technical or corrective maintenance.

Preventive Maintenance

Preventive maintenance is defined as those actions performed on equipment to maintain uninterrupted operation within design characteristics or to detect and/or prevent failures before they occur.

Technical/Corrective Maintenance

Technical maintenance may be defined as the correction of electronic equipment failures to allow restoration to proper operation.

PREVENTIVE MAINTENANCE

THE 3-M SYSTEMS

The Navy Maintenance and Material Management (3-M) Systems have been implemented in the Navy as an answer to the ever-present problem of maintaining a high degree of readiness. Although the 3-M Systems are designed to improve the degree of readiness, its effectiveness and reliability depend on the individuals concerned. The accuracy with which you perform your work, together with the neat and comprehensive recording of required data on prescribed forms are key factors in determining the degree of readiness of a command. Therefore, the importance of this preventive maintenance system cannot be over stressed.

The Navy 3-M (Maintenance and Material Management) Systems are the standards for maintenance and management of electronic equipment. NAVSECGRU Instruction 4790.4, *3-M Maintenance and Material Management Manual for Naval Security Group* contains guidance concerning the implementation and continuation of this highly effective maintenance program within the Naval Security Group. It provides all maintenance and material managers throughout the Naval Security Group with the means to plan, acquire, organize, direct, control, and evaluate manpower and material resources expended or planned for expenditure in support of maintenance.

The two basic systems of the 3-M Systems are the Planned Maintenance System (PMS) and the Maintenance Data System (MDS).

Planned Maintenance System (PMS)

PMS provides each field site with a simple and standard means for planning, scheduling, controlling and performing planned maintenance on equipment. PMS documents specify the minimum effort required to maintain equipment in a fully operational condition within design specifications. These maintenance actions, when performed according to schedule, provide the means to identify parts requiring replacement prior to failure. Thus, PMS procedures help to minimize future equipment failures which might otherwise result in repeated corrective maintenance actions thereby increasing equipment non-availability. These PMS procedures and the periodicity in which they are to be accomplished are developed for each piece of equipment based on good engineering practices, practical experience and technical standards.

MRC's (Maintenance Requirement Cards).—The MRC cards (see figure 9-1) provide the detailed procedures for performing the preventive maintenance and state exactly who, what, when, how, and with what resources a specific requirement is to be accomplished. MRC's contain the following information and instructions:

1. Identification of the system, subsystem, or component involved.
2. The MRC code, which is a code assigned to the card, consists of two parts. The first part of the MRC code corresponds to the first portion of the number identifying the applicable MIP (Maintenance Index Page) (explained later in this chapter); the second part identifies the periodicity for the maintenance action using a letter code for repetitive time element as follows:

D-Daily
W-Weekly
M-Monthly
Q-Quarterly
S-Semiannually
A-Annually
C-Cycle (Once every 36 months, unless otherwise specified on the MIP)

R—As required (maintenance requirements which are to be performed as indicated by a "situation" other than calendar periodicity).
U—Unscheduled (maintenance performed on equipment as directed on specific MRC's annotated "Unscheduled Maintenance").

18M - each 18 months 24M - each 24 months 36M - each 36 months 48M - each 48 months 60M - each 60 months	These codes are used with the R and U periodicity codes.

The periodicity code also includes a number for specific identification when more than one MRC of the same periodicity exists in the same MRC set. In most cases, the MRC's will be numbered consecutively. Technically, valid MRC's will not be reprinted merely to change the periodicity code number. Nonsequential numbers will not affect scheduling or management control. Situation requirement codes may be used with a calendar periodicity code in certain circumstances. These situations fall within two general categories:

a. When the situation governs the scheduling of the requirements, and
b. When the calendar periodicity governs the scheduling of the requirement.

The first category above considers the occasion of measuring values weekly when a certain system is in operation. The measuring of these values will not be required when the equipment is not being operated. This is an example of requirements that must be scheduled with regard to the situation rather than the calendar contingency. An example of a situation-calendar periodicity code is "R-1W". This code shows that when the equipment is in use, the maintenance action is accomplished weekly. This means that the R-1W code is entered into a daily column of the weekly schedule when the equipment is in use. During non-usage times, R-1W should be noted in the OUTSTANDING REPAIRS AND PM CHECKS DUE IN 4 WEEKS column without being scheduled.

When the periodicity code is of the calendar-situation combination (b. above) the calendar controls the scheduling and is only

SYSTEM	COMPONENT	MRC CODE	
Communications and Data	TSEC/KWR-37 Receiver	C-198	M-1
SUBSYSTEM	**RELATED MAINTENANCE**	**RATES**	**M/H**
Cryptographic Equipment	None	ET1437/ CT48JW	0.2

MAINTENANCE REQUIREMENT DESCRIPTION

1. Adjust voltages, loop current, and shunt balance.

TOTAL M/H 0.2

ELAPSED TIME 0.2

SAFETY PRECAUTIONS

1. Forces Afloat comply with NAVY SAFETY PRECAUTIONS FOR FORCES AFLOAT, OPNAVINST 5100 series; Shore Activities comply with SAFETY PRECAUTIONS FOR SHORE ACTIVITIES, NAVMAT P-5100 series.

TOOLS, PARTS, MATERIALS, TEST EQUIPMENT

1. 2" Light duty screwdriver

PROCEDURE

1. Adjust Voltages, Loop Current, and Shunt Balance.
   - a. Set power switch to ON.
   - b. Extend the receiver drawer to fully locked position; unlock and open the card reader.
   - c. Depress the SET-UP button.
   - d. Adjust power supply voltages:
     - (1) Set VOLTAGE-CURRENT switch to +30. Adjust DD-R2 for a red line indication on meter.
     - (2) Set VOLTAGE-CURRENT switch to +60. Adjust DD-R11 for a red line indication on meter.
     - (3) Set VOLTAGE-CURRENT switch to +1.25 position. Adjust CC-R8 for a red line indication on meter.
     - (4) Set VOLTAGE-CURRENT switch to -60. Adjust DD-R18 for a red line indication on meter.
   - e. Ensure that input and output loops are complete.

NOTE 1: Step 1.f. does not apply if Part 1, Mod 8, KAB-193A has been installed.

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LOCATION | DATE March 1976

MAINTENANCE REQUIREMENT CARD (MRC)
OPNAV 4700-1 (A) (REV. 3-69)

Procedure (Cont'd)

- **f. Set VOLTAGE-CURRENT switch to INPUT CURRENT. Hold the input signal to a mark condition and adjust INPUT LOOP control 4-R7 for a 60 milliamp red line indication on panel meter.**

NOTE 2: Steps 1.g., 1.h., and 1.i. do not apply if Part 2, Mod 8, KAB-193A has been installed. OUTPUT MARK, SHUNT BALANCE MARK, and SPACE cannot be adjusted and should indicate approximately red line.

- **g. Set VOLTAGE-CURRENT switch to OUTPUT MARK. Adjust OUTPUT LOOP control 4-R2 for a 60 milliamp red line indication on panel meter.**
- **h. Set VOLTAGE-CURRENT switch to SHUNT BALANCE SPACE position and note meter indication.**
- **i. Set VOLTAGE-CURRENT switch to SHUNT BALANCE MARK position and adjust BB-R4 to obtain same indication as noted in step 1.h.**
- **j. Set VOLTAGE-CURRENT switch to OFF.**
- **k. Return equipment to normal readiness condition.**

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MAINTENANCE REQUIREMENT CARD (MRC)
OPNAV 4700-1 (E) (REV. 3-69)

1.467

Figure 9-1.—Maintenance Requirement Card (MRC) (Front and Back).

occasionally overtaken by the situation. The calendar periodicity shall be referred to first in the code (e.g., 18M-2R). The 18M indicates that the longest time between accomplishment is every 18 months, and it should be scheduled thus; however, a situation could arise which would require it to be done more often.

3. Related Maintenance. This item is for a listing of actions on other MRC's in the same set which can be efficiently done prior to, with or immediately after, an action described on the basic MRC.

4. Maintenance Requirement Description. A brief description of the PMS action to be done.

5. Rates. The minimum skill levels of the men who should do the work, identified by rate or NEC.

6. M/H (Manhours). The average time per equipment required to do the maintenance. Total M/H and total elapsed time to the nearest tenth of an hour for each equipment are also listed. It does not include time for tool preparation and return.

7. Safety Precautions. A listing of warnings and cautions which direct attention to possible hazards to personnel or equipment while doing maintenance.

8. Tools, Parts, Materials, Test Equipment. Those tools, parts and materials necessary for the maintenance action.

9. Procedure. The sequence of detailed steps to be followed in doing the maintenance action.

10. Location. The location of the equipment; or is used for alerting maintenance personnel to the existence of Equipment Guide Lists (EGL).

11. Date. The month and year when the MRC was prepared.

12. SYSCOM MRC Control Number. Numbers located vertically along the lower right side of the MRC. It is a library identification number which, with the MRC code, identifies each MRC. A "Y" in the lower right block indicates that logistic support is required; an "N" indicates that logistic support is not required.

EGL (EQUIPMENT GUIDE LIST).–The EGL (figure 9-2) is a card which is used with a controlling MRC for those equipments made up of a number of identical items; i.e.,

C 2Ø/1-C6 Equipment Guide List	Page 3 of 6		
Nomenclature/Type	**Serial No.**	**Location/Custody**	**Remarks**
RECEIVER/R-39Ø/URR	5188	MBT-2Ø4 LOP 6	
RECEIVER/R-39ØA/URR	1527	MBT-2Ø4 LOP 6	
RECEIVER/R-39ØA/URR	227Ø	MBT-2Ø4 LOP 7	
RECEIVER/R-39ØA/URR	3469	MBT-2Ø4 LOP 7	

1.468

Figure 9-2.–Equipment Guide List (EGL).

multicouplers, receivers, etc. In determining the number of items to include on an EGL, the skill level of the technician and the time to do the maintenance on each item should be considered. Each EGL should contain no more than a single day's work. If more than one day is required, separate EGL pages are prepared for each, and numbered consecutively (e.g., "Page 1 of 2", "Page 2 of 2", etc.). A complete working deck of MRCs and applicable EGLs shall be located in the holder provided in the work center area. Maintenance personnel will remove the applicable MRCs and EGLs required to perform the maintenance actions. Upon completion of the maintenance action, the MRC and EGL shall be returned to its applicable place in the holder.

CHANGES TO MRCs.—Commander Naval Security Group Command (COMNAVSECGRU) will promulgate pen-and-ink changes correcting errors in PMS documentation affecting interim measures only for urgently required changes. Revised MRCs with the corrected or modified information will be provided by COMNAVSECGRU to the appropriate Naval Sea Support Center Pacific (NAVSEACENPAC) or Atlantic (NAVSEACENLANT) who will distribute them as appropriate. When changes to the maintenance procedures or periodicity for a specific MRC appear necessary or desirable, suggested changes should be forwarded to NAVSEACENPAC or LANT via COMNAVSECGRU using a PMS Feedback Report. MRCs affected shall be fully identified by citing the SYSCOM control number (see Item 12 above), subsystem, component, the applicable MRC code and complete MIP CONTROL NUMBER. Recommended changes shall be complete and include all information available. Each command has the prerogative of temporarily increasing the frequency for performance of specified planned maintenance actions to meet local conditions.

MAINTENANCE INDEX PAGE (MIP).—An MIP (figure 9-3) contains a brief description of the requirements on the MRCs for each item of equipment including; the periodicity code, the manhours involved, the minimum required skill level and, if applicable, related maintenance that can be done at the same time. The MIPs for all equipment in a department are contained in a master PMS record. This master PMS record also contains an index of the effective MIPs called an LOEP (List of Effective Pages) (figure 9-4) and a correction page to record changes made. The Master PMS Record is located in the maintenance office and is used as a management tool for scheduling maintenance on the PMS schedule forms and also as a cross-reference guide. Additionally, each work center has a Work Center PMS Record which is identical to the Master PMS Record except that it contains only those MIPs and LOEPs applicable to the work center. The work center supervisors, maintenance personnel and other maintenance related personnel can also use these records for cross-reference purposes.

PMS SCHEDULES.—The PMS schedules are categorized as annual, quarterly and weekly schedules.

Annual Schedules.—The annual schedule (figure 9-5) displays the planned maintenance requirements to be performed during the year. The annual PMS schedule contains the following information: Station UIC, work center designator, date of preparation, department head signature, MIP code, component upon which maintenance performed on and the periodicity code. The annual schedules are used to plan and schedule maintenance requirements for each calendar year. The EMO should devote considerable attention to the preparation of the annual schedule.

Quarterly Schedules.—The quarterly PMS schedule (figure 9-6) is a visual display of each work center's PMS requirement to be performed during a specific three-month period. This schedule, when updated weekly, provides a ready reference on the current status of PMS for each work center. The quarterly PMS schedule contains the following information: work center code, date, quarter, approval signature, MIP code and periodicity. The quarterly PMS schedule serves as a directive for work center supervisors for scheduling weekly maintenance.

Weekly PMS Schedule.—The weekly PMS schedule (figure 9-7) is a visual display of the

SYSTEM, SUBSYSTEM, OR EQUIPMENT	REFERENCE PUBLICATIONS	DATE
R-390,390A/URR Radio Receiver	R-390A/URR: NAVSHIPS 0967-LP-063-2010	December 1976 R-390/URR: TM 11-5820-10 TM 11-5820-20 TM 11-5820-35

CONFIGURATION:

R-390/URR FC 1, 2
R-390A/URR FC 1 through 8

SYSCOM MRC CONTROL NO.	MAINTENANCE REQUIREMENT	PERIODICITY CODE	SKILL LEVEL	MAN HOURS	RELATED MAINTENANCE
T 96 BUF4 N	1. Test tuning system and measure calibration oscillator signal level. 2. Test BFO operation.	M-1	RMSN RMSN	0.6 0.2	None
T C6 BWT7 N	1. Adjust IF gain. 2. Test audio gain. 3. Measure receiver sensitivity.	Q-1	ETN3	0.5	None
T C4 BAN1 N	1. Test VFO setting. 2. Test calibration oscillator.	S-1	RM3	0.3	None
C4 BAN2 N	1. Clean and inspect radio receiver. 2. Lubricate mechanical tuning system.	A-1	ETNSN	1.5	M-1

MAINTENANCE INDEX PAGE (MIP)
OPNAV 4700-3( ) (REV.)

PAGE 1 OF 1

SYSCOM MIP CONTROL NUMBER C-20/1-C6

1.469

Figure 9-3.—Maintenance Index Page (MIP).

REPORT NO. PMS 5 VAL SEA SUPPORT CENTER ATLANTIC CODE 97 REPORT DATE 05/07/76
PLANNED MAINTENANCE SYSTEM AUTOMATED QFR2-76
NAVAL TECHNICAL TRAINING COMMANDS ATLANTIC LIST OF EFFECTIVE PAGES *(LOEP) PAGE 1 152

UNIT -- 00063082 UIC -- 063082 WORK CENTER -- TS21 NTTC CORRY STA PNCLA

LINE ITEM	MIP	NOMENCLATURE	CID/APL/TM	QTY	EQUIP STAT	ADDS/ CHANGES
0010	C	SB-3145/UG			NMR	
0020	C	AN/FRD-10A(V)			MRS	
0030	C	OA-4412(V)/FLR-11			MRS	
0040	C	AN/GGC-15(V)6			MRS	/
0050	C	AN/GSH-14			MRS	
0060	C	C-8803/GRR			MRS	
0070	C	CN-1196/U			MRS	
0080	C	PD-4995/UG			MRS	
0090	C	R-1274A/URR			MRS	
0100	C	RE-1026/UG			MRS	
0110	C	SA-1716/U			MRS	
0120	C	SB-3142/UG			MRS	
0130	C	SB-3146/UG			MRS	
0140	C	SB-3148/UG			MRS	
0150	C	SB-3149/UG			MRS	
0160	C	SB-3150/UG			MRS	
0170	C	SB-3165/UG			MRS	
0180	C	SB-3166/UG			MRS	
0190	C	SB-3168/UG			MRS	
0200	C	TT-306A/UG			MRS	/
0210	C - 020/001-C4	R-390A/URR				
0220	C - 070/001-82	AT-3170/BRR				
0230	C - 089/001-C5	AN/UGC-5				/
0240	C - 089/011-C5	AN/UGC-5 (MK-1087/UG)				/
0250	C - 291/001-A4	AN/GSH-24(V)				
0260	C - 378/001-95	R-1279D/URR				
0270	C - 488/001-45	AN/UGC-50				/
0280	C - 489/001-93	AN/UGC-49				/
0290	C - 492/001-34	AN/FSQ-59(V)				
0300	C - 492/001-34	OL-17(V)/FSQ-59V				
0310	C - 493/001-64	AN/FSH-5				
0320	C - 494/001-C5	AN/FSH-7				
0330	C - 510/001-53	AN/FGC-60( )				
0340	C - 532/001-64	AN/FYA-7(V)				
0350	C - 534/001-15	AN/UGC-47				/
0360	C - 534/001-15	AN/UGC-51				/
0370	C - 534/001-15	TT/307A/UG				/
0490	C - 960/001-94	AN/FRQ-15(V)	54867515CL			
0500	C - 965/001-64	OA-4414F				
0510	C - 965/001-64	SB-1876A/F			NIR	

1.470

Figure 9-4.—List of Effective Pages (LOEP).

planned maintenance scheduled for accomplishment in a given work center during a specific week. A weekly PMS schedule is posted in each work center and used by the work center supervisor to assign and monitor the accomplishment of required PMS tasks by work center personnel. The PMS schedule contains the following information: work center code, date of current week, work center supervisor's signature, MIP code minus the date code, a list of applicable components, maintenance responsibilities assigned by name to each line of
169 equipment, the periodicity code of the maintenance requirements to be performed, and major repairs outstanding. The weekly schedules are used to obtain completed and deferred maintenance actions.

SCHEDULING EXCEPTIONS.—Upon review of an MIP, it may be determined that certain maintenance requirements are not applicable. In such instances, the following actions should be taken:

1. If authorized by a management aid, strike a line through the requirements on the MIP and have the deletion initialed by the EMO.

(DEPT HEAD)

STATION: 63887 | MAINTENANCE GROUP: BSBZ | SCHEDULE MAINTENANCE AS INDICATED | DATE PREPARED AND AUTHENTICATED BY

MIP CODE	COMPONENT	(1) JAN FEB MAR	(2) APR MAY JUN	(3) JUL AUG SEPT	(4) OCT NOV DEC	EACH QUARTER
C-291/1-A4	AN/GSH-24(A-2)					R-1,M-1,Q-1
C-291/1-A4	AN/GSH-24(A-7)					R-1,M-1,Q-1
C-2Ø/1-96	R-390A (1Ø17)	S-1,A-1		S-1		M-1,Q-1
C-2Ø/1-96	R-390A(2Ø31)		S-1,A-1		S-1	M-1,Q-1
C-2Ø/1-96	R-390A(1712)	S-1		S-1,A-1		M-1,Q-1
C-3Ø4/6-66	R-1Ø51D (12)		S-1,S-4		S-1,S-4	M-1R,Q-1R
C-485/1-56	AN/GYK-22(B-2)					Q-1
T-1/1-96	TEST EQUIP(EGL)					R-1, M-2
C-23Ø/1-96	R-1274 (A133)	S-1		S-1		R-1

ANNUAL SCHEDULE 11ND-SUPSHIP(MMFO)-SD-5330/15 (4-71)

Figure 9-5.—Annual PMS Schedule. 1.471

(DEPT HEAD)

MAINTENANCE GROUP: BSBZ | YEAR: 1977 | CALENDAR QUARTER: SECOND | AUTHENTICATED BY: LT

MIP CODE	APR 4	11	18	25	MAY 2	9	16	23	30	JUN 6	13	20	27	RESCHEDULE
C-291/A-2	~~M-1~~					~~M-1,Q-1~~				M-1				
C-291/A-7		M-1					M-1,Q-1				M-1			
C-2Ø/1Ø17			M-1	~~M-1~~				M-1				M-1,Q-1		
C-2Ø/2Ø31				~~M-1,Q-1 S-1,A-1~~				M-1				M-1		
C-2Ø/1712	~~M-1~~				~~M-1,Q-1~~				M-1				M-1	
C-3Ø4/12			M-1R,Q-1R S-1, S-4				M-1R				M-1R			
C-485/B2									Q-1					
T-1/EGL	~~M-2,R-1 EGL (P-1)~~				~~M-2,R-1 EGL (P-2)~~				M-2,R-1 EGL (P-3)				M-2,R-1 EGL (P-4)	
C-230/A133														

NOTE: X - INDICATES COMPLETED PM

O - INDICATES RESCHEDULED PM

QUARTERLY SCHEDULE 11ND-NAVSEACENPAC-5330/14 (3-76)

U.S. GOVERNMENT PRINTING OFFICE 1976

Figure 9-6.—Quarterly PMS Schedule. 1.472

WEEKLY PMS SCHEDULE (CONVENTIONAL)
OPNAV FORM 4790/15 (3-71)
S/N 0107-LF-770-3260

(DIVISION OFFICER) ★U.S. GPO: 1973—710-239

WORK CENTER	PMS SCHEDULE FOR WEEK OF	APPROVAL SIGNATURE
BSBZ	16—23 MAY	

MIP	COMPONENT	MAINTENANCE RESPONSIBILITY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT.-SUN.	OUTSTANDING REPAIRS AND P.M. CHECKS DUE IN NEXT 4 WEEKS
C-291/1-A4	AN/GSH-24(A2)	CTM3 DAY	W-1						R-1, M-1
C-291/1-A4	AN/GSH-24(A1)	CTM3 DAY	W-1 M-1, Q1						R-1, M-1
C-2Ø/1-96	R-39ØA(1Ø17)	CTM3 LANE							M-1
"	" (2Ø31)	"							M-1
"	(1712)	"							M-1
C-3Ø4/6-66	R-1Ø51D(12)	CTM2 BAHILL	W-1, M-1R			W-1, M-1R			M-1R
C-485/1-56	AN/GYK-22(B2)	CTM3 LEE	W-1						Q-1
T-1/1-96	TEST EQUIP(EGL)	CTM2 MUZA							M-2 R-1 EGL(P-3)
C-23Ø/1-96	R-1279(A-133)	CTM3 ELMORE	D-1	D-1	D-1	D-1	D-1	D-1 D-1	R-1

UPDATE THIS SCHEDULE DAILY

1.473

Figure 9-7.—Weekly PMS Schedule.

2. If not authorized by a management aid, a PMS feedback report must be submitted to identify the reason for non-applicability. No change shall be made to the MRC until authorized; however, scheduling of such procedures may be discontinued.

There will be instances when an MIP will include a requirement for more than one work center to participate in the performance of specified maintenance actions. If this is the case, the following procedures will apply:

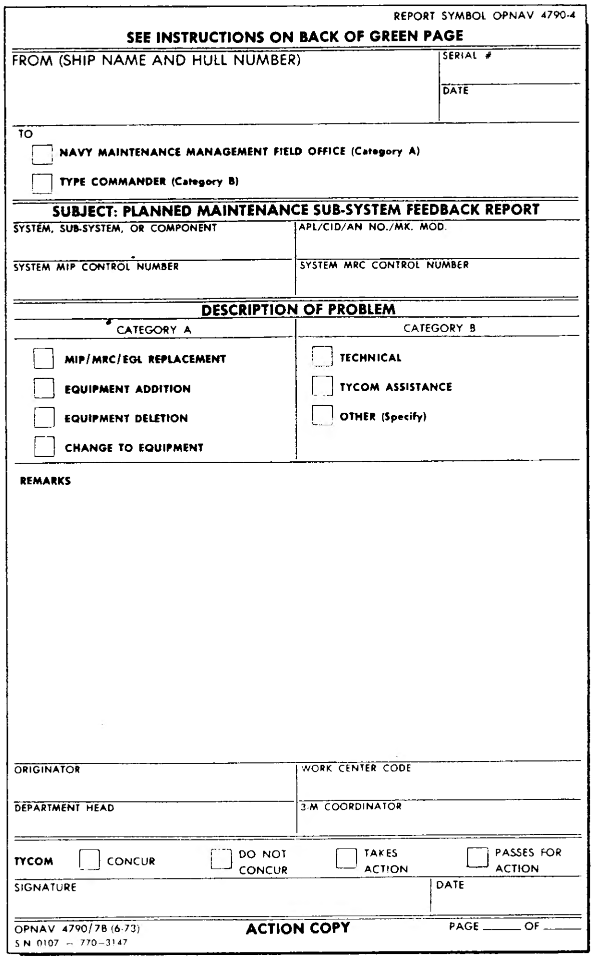
1. Submit a feedback report to notify COMNAVSECGRU of the decision to split the maintenance responsibility, as well as requesting additional MIP's to ensure an adequate number for the work centers concerned.

2. Insert the MIPs into the work center manuals and add equipment to the applicable LOEPs.

3. If the annual PMS schedule does not reflect the equipment, add the equipment nomenclature to the schedule.

4. Distribute the MRCs and EGLs to the work center concerned.

PMS FBR (FEEDBACK REPORT).—The PMS FBR (figure 9-8) is a form used by field site personnel to notify NAVSEASUPCEN or COMNAVSECGRU, as applicable, on matters related to PMS. The report is a five-part form



REPORT SYMBOL OPNAV 4790-4

SEE INSTRUCTIONS ON BACK OF GREEN PAGE

FROM (SHIP NAME AND HULL NUMBER) | SERIAL # | DATE

TO
- NAVY MAINTENANCE MANAGEMENT FIELD OFFICE (Category A)
- TYPE COMMANDER (Category B)

SUBJECT: PLANNED MAINTENANCE SUB-SYSTEM FEEDBACK REPORT

SYSTEM, SUB-SYSTEM, OR COMPONENT | APL/CID/AN NO./MK. MOD.

SYSTEM MIP CONTROL NUMBER | SYSTEM MRC CONTROL NUMBER

DESCRIPTION OF PROBLEM

CATEGORY A	CATEGORY B
MIP/MRC/EGL REPLACEMENT	TECHNICAL
EQUIPMENT ADDITION	TYCOM ASSISTANCE
EQUIPMENT DELETION	OTHER (Specify)
CHANGE TO EQUIPMENT	

REMARKS

ORIGINATOR | WORK CENTER CODE

DEPARTMENT HEAD | 3-M COORDINATOR

TYCOM — CONCUR — DO NOT CONCUR — TAKES ACTION — PASSES FOR ACTION

SIGNATURE | DATE

OPNAV 4790/78 (6-73) S/N 0107-770-3147 — ACTION COPY — PAGE ___ OF ___

1.474

Figure 9-8.—Blank PMS Feedback Report (FBR).

composed of an original and four copies. Instructions for preparation and submission of the form are printed on the back of the last copy. These forms are obtainable through the Navy Supply System.

PMS FBR CATEGORIES.—There are two categories of FBRs—Category A and Category B. These categories are defined as follows:

Category A (Administrative). To reduce response time, these FBRs (yellow and white copies) are submitted directly to NAVSEACENPAC or LANT by the 3-M Coordinator (pink copy to COMNAVSECGRU) and pertain to the following: The need for replacement of missing or mutilated MIPs, MRCs or EGLs; equipment added to a work center which was not previously listed in the same work center; equipment changes caused by incorporation of alternations or field changes; the deletion of the last system or equipment component in a work center; the establishment of a new center; the deletion of an existing work center; and the change of equipment from one work center to another.

Category B (Technical). These FBRs (white, yellow and pink) are submitted by the station's 3-M coordinator to NAVSEACENPAC or NAVSEACENLANT via COMNAVSECGRU, and pertain to technical discrepancies such as; discrepancies discovered in PMS documentation; or discrepancies discovered in design, maintainability, reliability, or operation, including comments about deficiencies in PMS support. Category B FBRs are also submitted when requesting assistance in the clarification of the 3-M instructions.

PMS SAFETY PRECAUTIONS.—The necessity of making all personnel safety conscious cannot be overemphasized. Every effort has been made to indicate hazards to personnel in the "Safety Precautions" block of the MRCs. Although this information is inserted immediately prior to the appropriate procedural step, common sense, through indoctrination and training of all personnel maintaining and operating NAVSECGRU equipment, is still required. Inadequacies in the MRC or other technical documentation which could affect the safety of personnel or equipment should be reported on an urgent PMS FBR.

Maintenance Data System (MDS)

The Maintenance Data System was conceived for the purpose of standardizing documentation procedures and to provide a media by which information concerning shore maintenance and maintenance support actions can be made readily available to various levels of management. Maintenance personnel will be

required to collect and record required information once and only once. The Maintenance data banks will thereafter provide information to all who have a need for it, in such form as may be required. The effectiveness of the Maintenance Data System is dependent upon the accuracy, completeness, and timeliness of the information documented and forwarded by each activity. COMNAVSECGRU and the Systems Commands have numerous programs for improving equipment reliability, maintainability, logistic and personnel support of equipments and they are all dependent on conscientious data reporting.

Standardized maintenance procedures and documents have been developed to improve maintenance management of hardware resources. MDS (Maintenance Data Systems) is the only method for collecting maintenance data in the Naval Security Group. The 4790.4 Maintenance Action Form (See Figures 9-10 and 9-11) was developed to obviate the requirement for any other form, local or command, to be used in the maintenance management of each piece of electronic or electromechanical equipment under the management control of COMNAVSECGRU and to permit the easy recording and submittal of data to all who have a need for this information.

The 4790.4 form requires only information which is essential to the maintenance data system. The format is such that it can be easily utilized by maintenance personnel and will facilitate a smooth transition into message format or punch cards by communications or card punch personnel.

TYPES OF MDS REPORTS.—There are two types of reports required dependent upon the status of the corrective maintenance action. These reports are defined as follows:

Completed Maintenance Action.—A completed maintenance action is submitted when the desired result has been realized within seven days and no further action is required. Equipment returned to service by the replacement of a printed circuit card or subchassis is treated as a completed action only if the replaced card or subchassis is repaired within the seven day limit. The incorporation of a completed field change into an equipment is a completed maintenance action.

Deferred Maintenance Action.—A deferred maintenance action is one that cannot be promptly completed because the need for outside assistance such as technical aid, supply support, order of priorities or other similar matters. Deferred maintenance actions will be submitted in the next weekly report after it has been determined that a maintenance action will not be completed within seven days.

JOB CONTROL NUMBER LOG.—A locally generated Job Control Number Log shall be maintained by each work center supervisor utilizing the format in Figure 9-9. This log will contain the following information: JSN (Job Sequence Number), local control number if used, transmission identification data (Julian Date maintenance information data was transmitted to MSOD) to be furnished by communications personnel; equipment nomenclature, and remarks (to be utilized by work center supervisor as required, but should indicate deferrals and the name of the maintenance technician assigned, requisition numbers of parts ordered, etc.). The work center supervisor will assign a separate JSN for each maintenance action reported from that work center. These JSN's shall be in sequential order and logged into the JCN log. The Electronics Maintenance Officer (EMO) or 3-M Coordinator shall frequently check the work center logs for proper accountability and timeliness of submission.

COMPLETING THE 4790.4 MAINTENANCE ACTION FORM.—The following instructions refer to the Maintenance Action Form. If the action being reported is a "Completed Action", only the Completed Action portion of Section I need be filled out. Conversely if the action being reported is a deferment, only the Deferred Action section need be completed. Sections II and III apply to both types of maintenance actions and are to be used as required.

UIC-7ØØ92				WC-BSBZ
JSN	LOCAL CONTROL	DATE	NOMENCLATURE	REMARKS
Ø157	Ø215	5247	R-123Ø/FLR	CTM2 G. SMITH DEFERRED FOR C1Ø1
Ø158	Ø237	526Ø	R-39ØA	
Ø159	Ø258	5265	RD-311/FSH-7	
Ø16Ø	Ø3Ø2	53Ø1	AM-14Ø7	
Ø161	Ø313	53Ø3	CAQI-5245	
Ø162	Ø314	53Ø3	R-123Ø/FLR	AWAITING RL2. ACTION DEFERRED--CTM3 GABRIELSON

1.475

Figure 9-9.—Sample Page From a Job Control Number Log.

SECTION I—COMPLETED MAINTENANCE ACTION (SEE FIGURE 9-10)

Block 1 UIC (Unit Identification Code). Enter the UIC of the originating station. If the UIC is only four digits, add a Ø to the left of the UIC.

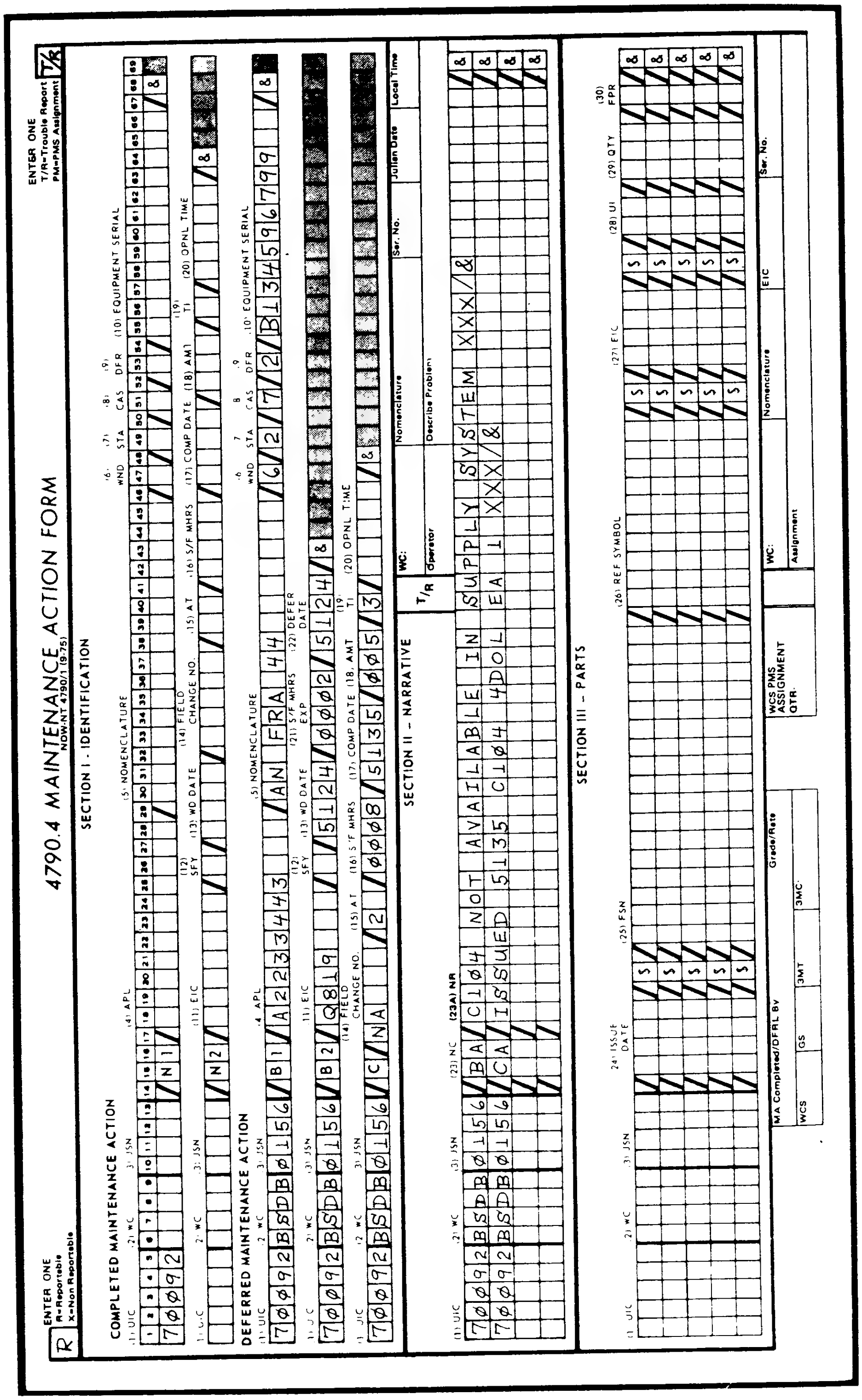
Block 2 WC (Work Center). Enter the four letter codes assigned to the work center submitting the maintenance action.

Block 3 JSN (Job Sequence Number). Enter the sequence number assigned by the work center supervisor. Add zeros to left of number if necessary to make a four digit number and ensure that it is logged in the JCN log. Numbers are to be used only once in any work center.

Block 4 APL (Allowance Parts List). Enter the APL number in this block starting at the left hand side. Enter the APL Number appearing in the PIES #E2005, Master Equipment Inventory List (Procurement and Inventory of Equipment System is discussed in Chapter 10). Leave remaining spaces blank. Enter "NA" if APL number is not available.

Block 5 Nomenclature. Enter the AN nomenclature or manufacturers code as it appears in the PIES #E2008, Master Nomenclature List. Do not use the hypen (-), slant (/), bar or parenthesis. Use a space in lieu of these special characters. Make the entry in the left hand side of the block and leave any remaining spaces blank.

Block 6 WND (When Discovered). Enter the selected code from Appendix A of NAVSECGRUINST 4790.4 which best describes when the malfunction was discovered.



1.476

Figure 9-10.—Sample of a Completed Maintenance Action.

Block 7 STA (status). Enter the selected code from Appendix A of NAVSECGRUINST 4790.4 that described the effect of the failure on the equipment capability to perform its assigned mission. If this maintenance action is on a sub-assembly or circuit board of an equipment already repaired and returned to service by the replacement of this sub-assembly or board, make sure that the Status Code 1 is entered to show that the equipment is fully operational.

Block 8 CAS (Cause). Enter the code that best describes, in the maintenance person's opinion, the cause of the malfunction. Select this code from Appendix A of NAVSECGRU Instruction 4790.4.

Block 9 DFR (Deferral Reason). Enter the deferral code from Appendix A of NAVSECGRUINST 4790.4 that best describes the reason maintenance could not be done at the time of deferral. Enter only an "O" in this block in the Completed Maintenance Action Section.

Block 10 Equipment Serial. Enter the equipment serial number as listed in the PIES #E2008, dropping all leading zeros in the serial number. Start entry in the left hand side of the block. Leave remaining spaces blank. Use a space in place of all hypens (-) or slant (/) bars.

Block 11 EIC (Equipment Identification Code). Enter the EIC of the equipment on which maintenance is being performed. The EIC codes are listed in the PIES #E2008, Master Nomenclature List and Appendix F of NAVSECGRUINST 4790.4. Enter this code in the left hand side of the block and leave remaining spaces blank.

Block 12 SFY (Safety). Enter an "X" in this block for any maintenance action or occurrence that would relate to the safety of personnel or equipment. A brief description of this hazard shall appear in the narrative section. An entry in this section does not release the maintenance person from the responsibility for reporting this condition to his superiors so that action may be taken by other means. If this block does not apply to the maintenance action leave it blank.

Block 13 WD Date (When Discovered Date). Enter the Julian date the equipment or system failure was first discovered; i.e., 24 April 1978 enter 8114.

Block 14 Field Change No. Enter the number of the field change or modification work order. A field change will be indicated by the digraph "FC", modification work order by "MW", Cryptographic Modifications by "MOD", and modification kit by "MK" or "K" as space permits; e.g. entries will appear as FCØØ2, MWØ15, MOD21, MKØ21 or K11ØØ.

Block 15 AT (Action Taken). Enter the code from Appendix A of NAVSECGRUINST 4790.4 that best describes the situation. Enter in left hand side of block and leave the rest blank as applicable.

Block 16 S/F MHRS (Station Force Man Hours). Enter the number of man hours to the nearest whole number expended on the total maintenance action. In the case of completed maintenance actions, enter the total time expended. For completed deferred maintenance actions, enter only the time expended after the deferred maintenance action was reported i.e., two persons working for three hours is equal to six manhours. Enter this figure in the right hand side of the block. Enter zeros to the left to fill block as required.

Block 17 COMP DATE (Completion Date). Enter the Julian Date that the maintenance action was completed; e.g., for 5 May 1978 enter 8125.

Block 18 AMT (Active Maintenance Time). Enter, to the nearest whole hour, the number of clock hours during which maintenance was being performed, i.e., two persons worked for 3 hours and then had to wait 6 hours for parts. When the parts were received they worked for 2 more hours installing the parts to complete the maintenance action. The entry would be 3 + 2 or 5 hours; enter 005.

Block 19 TI (Trouble Isolation). Enter a single numeral to indicate to the nearest 10 percent, the percentage of maintenance (Block 18) clock hours expended in troubleshooting. For example: 2 = 20%, 3 - 30%, etc. If the total maintenance time was 10 hours and the total time spend in troubleshooting was two hours, then the percentage would be 20 percent: enter "2". Leave blank when reporting a field change.

Block 20 OPNL TIME (Operational Time). Enter the number of operational hours that the equipment has been in service since the last

recorded failure. This time will be taken from time meters or time cards and entered as the nearest whole hour. This entry is not required unless requested by special instructions. Enter in right side of block and fill blanks with zero's.

SECTION I
(DEFERRED ACTION)

The Blocks numbered 1 thru 20 are to be filled out, if applicable, as discussed under "Completed Maintenance Action." The following blocks are peculiar to the deferred action (see figure 9-11):

Block 21 S/F MHRS EXP (Station/Force Man Hours Expended). Enter the number of man hours, to the nearest whole hour, expended up to the time of the deferral on the particular maintenance action. Enter this number in the right side of the block and fill with zero's as necessary.

Block 22 DEFER DATE (Deferral Date). Enter the Julian date that the maintenance action was deferred, e.g., 24 April 1978 would be entered as 8114.

SECTION II
(NARRATIVE)

This section is provided for documenting comments considered pertinent to the maintenance action. Every maintenance action need not be accompanied by a narrative. Comments deemed necessary for clarity or required to amplify the coded information in section one are valid entries. It may be necessary to include comments relating to safety, historical interest, or some supply related information. The maintenance person should use his best judgment but should try not to reiterate information already coded in section one. The single "X" preceded and followed by a space will be used for punctuation in lieu of the period and termination of the narrative will be indicated by "XXX/&." The "/&" in Block 68 and 69 need not be repeated after a "XXX/&" termination. Additional narrative may be added at a later date even if "XXX/&" has been used.

SECTION II (FOR COMPLETED MAINTENANCE ACTION)

Block 23 NC (Narrative Code). When the narrative section is used, a sequential narrative code will be entered in this block for each line used. Codes are NA through NT; i.e. first line used will be coded NA, second line NB, third line NC, etc.

SECTION II (FOR DEFERRED MAINTENANCE ACTION)

Block 23 NC (Narrative Code). The narrative codes are entered for deferred actions in the same manner as for completed actions. However, for deferrals the codes assigned are BA through BT (Opening) and CA through CT (Closing).

Notes: (1) Remember each line (NA, NB, BA, BB, CA, CB, etc.) in the narrative section requires another card; therefore, comments should be kept as brief as possible.

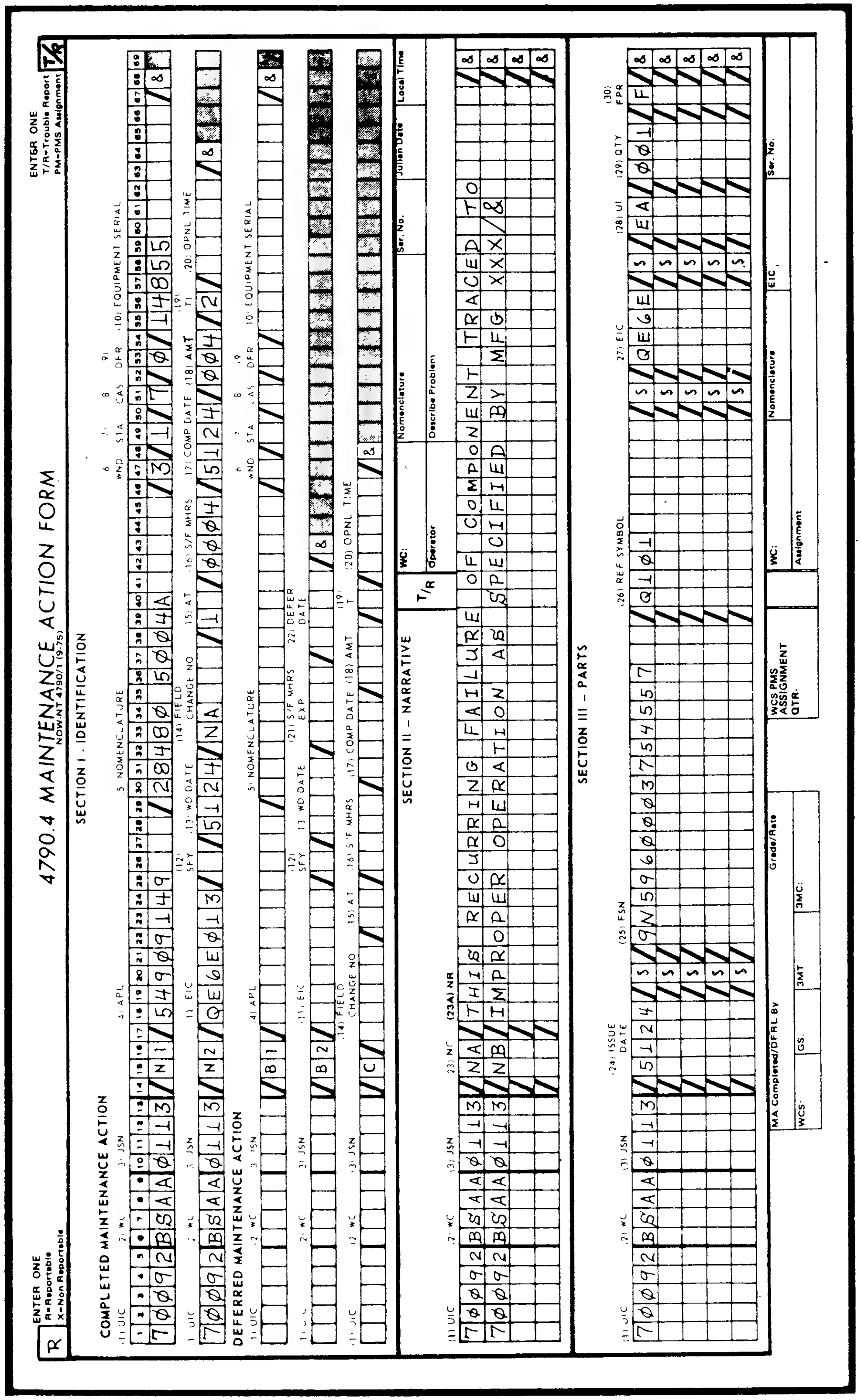
(2) A word should not be started at the end of a line if it cannot be completed on that line. Leave spaces and go to the next line as required.

SECTION III
(PARTS)

Blocks 1-3 are to be filled out as previously discussed.

Block 24 ISSUE DATE. Enter the Julian date that the part was issued from supply or pre-expended bins; i.e., part drawn on 24 April 1978 enter 8114.

Block 25 NSN (National Stock Number). Enter the COG symbol and National Stock Number of the supply part issued or used from the pre-expended bin. Enter this number in the left hand side of the space; entry will appear as 9N596000395077. If the part does not have an NSN you may use the FSCM (Federal Supply Code for Manufacturers) and the Manufacturers part number. The Part number is limited to eleven elements. Enter these numbers in the left hand side of the space and leave the remaining spaces blank: i.e., 51875_ 75R41781A_. Repair parts must be identifiable by NSN or



1.477

Figure 9-11.—Sample of a Deferred Maintenance Action.

FSCM and part number if they are to be logged in Section III. If they cannot be identified in this manner, they must be identified in a narrative comment which shall include the following information:

(1) Julian Issue Date. Required on deferred actions only.

(2) Reference Symbol or Description.

(3) Cost report to nearest whole dollar; i.e. $4.57 enter as 5DOL.

(4) Indicate whether item is considered failed part by the letter "F".

Block 26 REF SYMBOL (Reference Symbol). Enter the reference, circuit or component symbol as required; i.e., if a complete circuit board is replaced the entry would be 1A2A3A5. If a resistor or capacitor on the board were replaced then the entry would appear as 1A2A3A5R1 etc. Enter part number if a reference symbol is not indicated. Enter this symbol in the left hand side of the block. Leave remaining spaces blank. Parts having the same COG and NSN but different reference symbols should be reported as separate line entries.

Block 27. Enter the first four left hand characters of the EIC for the equipment in which the parts are to be utilized.

Block 28 UI (Unit Of Issue). Enter the unit of issue for the supply item, i.e., PK for package, EA for each, etc.

Block 29 QTY (Quantity). Enter the quantity of parts under the stock number used. Enter in right hand side of block and fill with zero's as necessary. A quantity of more than one should be explained in the narrative Section.

Block 30 FPR (Failed Part Reporting). Enter the letter "F" if in the maintenance person's opinion this is the primary part that was the cause of the ultimate failure. Only one part will be designated as the failed part on any one maintenance action. If not applicable leave blank.

Figure 9-11.—Sample of a Deferred Maintenance Action.

LOCALLY DEVELOPED SYSTEMS

Although the 3-M system is designed to cover preventive maintenance of all major electronic equipments aboard a station, other means must be devised to cover preventive maintenance of those equipments not covered by the 3-M system. Normally, the leading petty officer will organize a system of preventive maintenance for these equipments. Naturally, these locally developed systems will vary from command to command, however, if efficiently carried out, they will result in proper maintenance.

The Technical Manual

The most valuable aid to anyone developing a PM system is the applicable equipment technical manual. The technical manuals contain information concerning service and repair. This information is in the technical maintenance areas, and contains guidelines for preventive maintenance of that particular equipment. It will state for instance, how often this equipment should receive preventive maintenance; contain a list of preventive maintenance procedures; and provide a listing of required test equipments, and maintenance standards.

Close adherence to these guidelines will help immeasurably in developing an effective preventive maintenance program.

Maintenance Check Lists

A preventive maintenance check list is an effective measure used to keep track of locally developed PM systems. The check list will normally contain a list of applicable equipments, the task required, the date due, and the date completed. The actual contents, and format of these check lists are dictated by requirements.

TECHNICAL MAINTENANCE

While preventive maintenance keeps electronic system failures to a minimum, failures will still occur. Timely and accurate correction of these failures are an important concern to the technician and other station personnel as they insure smooth, reliable operation of the electronic systems. Correction of these equipment failures comes under the classification of technical or corrective maintenance.

CORRECTIVE MAINTENANCE PROCEDURES

A technician may know the theory of operation and circuitry of the equipment under his charge so well that he can picture every component in his mind, but unless he knows and applies the proper troubleshooting techniques he will never become a good technician.

The basic element of troubleshooting, so frequently overlooked, is a logical approach to the problem.

A logical or systematic approach to troubleshooting is paramount in a technician's overall knowledge of electronics. Many man-hours have been lost because of the time consuming "hit-or-miss" methods of trouble analysis. Figure 9-12 illustrates the six-step trouble shooting procedure presented in this chapter which has been developed to give you a path to follow toward the ultimate goal of effective equipment maintenance and optimum operational capability. If you can grasp the concept and basic importance of the suggested troubleshooting steps explained briefly in the following paragraphs, you will gain the ability to troubleshoot any electronic equipment regardless of its complexity or purpose.

Symptom Recognition

This is the first step in our logical approach to trouble analysis. In order to repair an equipment you must first determine whether it is functioning correctly or incorrectly. All electronic equipments are designed to do a specific job or group of jobs according to the requirements established by the Navy and the equipment manufacturer. This demands that a certain type of performance be obtainable at all times.

For this reason the recognition of trouble symptoms is the first step in troubleshooting an equipment.

A trouble symptom is a sign or indicator of some disorder or malfunction in an electronic equipment. Symptom recognition is the act of identifying such a sign when it appears.

Since a trouble symptom is a manifestation of an undesirable change in equipment performance, we must have some standard of normal performance to serve as a guide. By

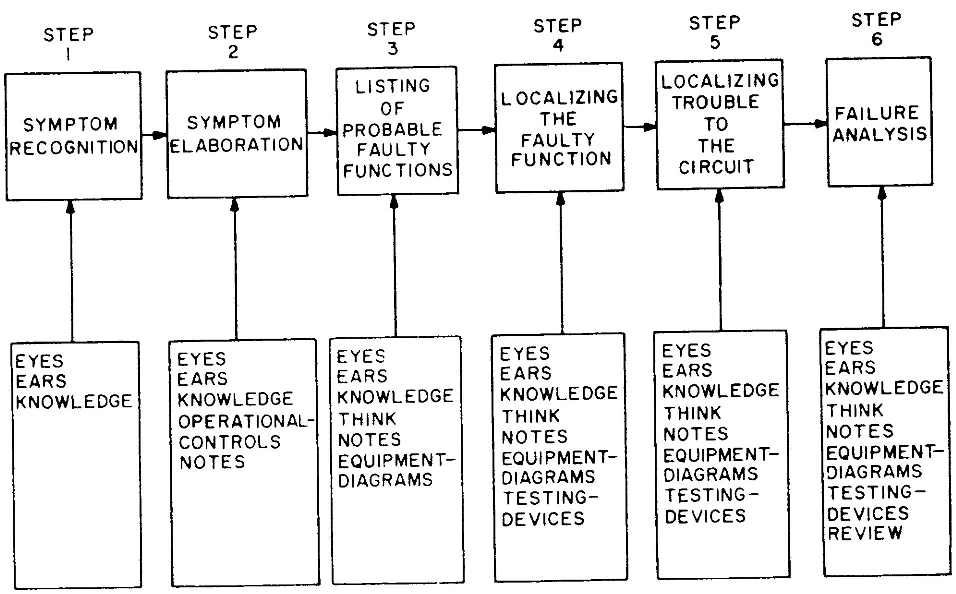


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Figure 9-12.—The Six-Step Procedure.

comparing the present performance with the normal, you can recognize that a trouble symptom exists and make a decision as to just "what" the symptom is.

When you have a fever or a headache, you know that there is a disorder somewhere in your body. When you hear a loud "knocking" sound in the engine of your car, you know that some part of the engine is not performing properly. Similarly, when you observe that the sound from a receiver is distorted, you know that there is a fault somewhere in the receiver or its supporting equipment.

Your normal body temperature is 98.6° Fahrenheit. A change above or below this temperature is an abnormal condition–a trouble symptom. If you determine that your body temperature is 102° F., by comparing this with the normal you can say that the symptom is an excess temperature of 3.4° F. Thus, you have exactly defined the symptom.

The normal sound from a superheterodyne receiver is a clearly understandable reproduction of the message sender's voice. If it sounds as though the sender is talking from the bottom of a barrel filled with water, the receiver operator knows that this distortion is a trouble symptom.

During the process of doing their assigned job, most electronic equipments yield information which an operator or technician can either see or hear. The senses of hearing and sight, therefore, allow you to recognize the symptoms of normal and abnormal equipment performance. The display of information may be the sole job of the equipment or it may be a secondary job to permit performance evaluation.

Electrical information, to be presented as sound, must be applied to a loudspeaker or a headset. A visual display results when the information is applied to a cathode-ray tube or to an indicating meter which is built into the equipment control panel and which can be viewed by the operator. Pilot lights also provide a visual indication of equipment operation.

Electronic equipment failure is the simplest type of trouble symptom to recognize. Equipment failure means that either the entire equipment or some part of the equipment is not functioning and will, therefore, show no performance display. The absence of sound from a superheterodyne receiver when all controls are in their proper positions indicates a complete or partial failure.

Even if the audible and visual information is present, the equipment may not be performing normally. Whenever the equipment is doing its job, but is presenting the operator with information that does not correspond with the design specifications, the performance is said to be degraded. Such performance must be corrected just as quickly as an equipment failure. This performance may range from a nearly perfect operating condition to the condition of barely operating.

Knowledge of the normal equipment displays will enable you to recognize an abnormal display, which provides the trouble symptoms we are concerned with in our first troubleshooting step.

Symptom Elaboration

As a second step, the obvious or not so obvious symptom should be further defined. Most electronic devices or systems have operational controls, additional indicating instruments other than the main indicating device, or other built-in aids for evaluating performance. These should be utilized at this point to see whether they will effect the symptom under observation or provide additional data that further defines the symptom.

Breaking out the test equipment and equipment diagrams and proceeding headlong into testing procedures on just the original recognition of a trouble symptom is an unrealistic approach. Unless you completely define a trouble symptom first, you can quickly and easily be led astray. The result, as before, would be loss of time, unnecessary expenditure of energy, and perhaps even a total dead-end approach. This step is the "I need more information" step in our systematic approach.

Symptom elaboration is the process of obtaining a more detailed description of the trouble symptom. Recognizing that the fluorescent screen of a cathode-ray tube is not lighted is not sufficient information for you to

decide exactly what could be causing the trouble. This symptom could mean that the cathode-ray tube is burned out, that there is some disorder in the internal circuitry associated with this tube, the intensity control is turned down too low, or even that the equipment is not turned on. Think of all the time you may waste if you tear into the equipment and begin testing procedures when all you may need to do is flip the "on-off" switch to "on", adjust the intensity control, or just plug in the main power cord.

Similarly, recognizing an undesirable hum in a superheterodyne receiver as a trouble symptom could lead you in several directions if you do not obtain a more detailed description of the symptom. This receiver hum may be due to poor filtering action in the power supply, heater-cathode leakage, a.c. line voltage interference, or other internal and/or external faults.

It should be apparent by now that the primary reason for placing symptom elaboration as the second step in our logical procedure is that many similar trouble symptoms can be caused by a large number of equipment faults. In order to proceed efficiently, it is necessary to make a valid decision as to which fault(s) is probably producing the specific symptom in question.

Symptom elaboration cannot be fully accomplished unless the observed displays can be completely evaluated. This means that the indications must be evaluated in relation to one another, as well as in relation to the overall operation of the equipment. The easiest method for accomplishing this evaluation is to have all data handy for reference by recording the information as it is obtained.

This will enable you to sit back a moment and "think" the information over before jumping to a conclusion as to where the trouble lies. It will also enable you to check the equipment manual and compare the information with detailed descriptions if this is necessary—a particularly useful technique for someone just becoming familiar with troubleshooting. Finally, by recording all control positions and the associated meter and indicator information, you can quickly reproduce the information and check to see that it is correct, as well as put the equipment in exactly the operating condition that you wish to test. Thus, the recording of information will enable you to save time and become a more efficient troubleshooter.

Whenever the adjustment of a control has no effect upon the symptom, this fact should also be recorded. This information may later prove to be just as important as any changes a control may produce in the trouble symptom. This procedure may seem unnecessary as this portion of the text is read, but it will definitely pay off in systematic trouble analysis. This fact will become more obvious as we probe deeper into the equipment under test.

Gaining further information about a trouble symptom by manipulating the operating controls and instruments will help you identify the probable faulty function required in the next step. This procedure will give you an estimate of where the trouble lies and will permit you to eventually classify the problem down to the exact item responsible.

If the trouble is cleared up by manipulating the controls, the trouble analysis may stop at this point. However, by using your knowledge of the equipment involved, you should find the reason why the specific control adjustment removed the apparent malfunction. This action is necessary to assure yourself, as well as the operator, that there are no additional faulty items which will produce the same trouble later.

In manipulating controls, you must be aware of the circuit area in which the control is located. Only those controls that will logically affect the indicated symptom should be adjusted. When adjusting controls, use extreme caution—a misadjustment may cause additional circuit damage.

Whether or not you will proceed from step 2 to step 3 (listing of probable faulty functions) or to step 5 (localizing trouble to the circuit) will depend on the number of units in the equipment and/or the complexity of a single-unit equipment, as previously described.

Listing of Probable Faulty Functions

The performance of the third step is dependent upon the information gathered in the

two previous steps. Step 1, remember, was "symptom recognition", that is, becoming aware of the fact that an equipment is performing its operational function in an abnormal manner. Step 2, symptom elaboration, allows you to use the operating controls and front-panel indicators to obtain as much information about the abnormality as you possibly can.

Step 3, listing of probable faulty functions, is applicable to equipments that contain more than one functional area or unit. It allows you to mentally select the functional unit (or units) which probably contains the malfunction, as indicated by the information obtained in steps 1 and 2. The selection is made by stopping to think, "Where can the trouble logically be in order to produce the information I have gathered?"

The term, function, is used here to denote an electronic operation performed by a specific area (or unit) of an equipment. A transceiver, for example, may include the following functional areas: transmitter, modulator, receiver, and power supply. The combined functions cause the equipment to perform the electronic purpose for which it was designed.

Frequently, the terms "function" (an operational sub-division of an equipment) and "unit" (its physical sub-division) are synonymous. A functional unit may be located in one or more physical locations. For example some components of a receiver, in a transceiver set, may be located in the transmitter compartment. Normally, the physical location, such as a drawer containing a receiver, is referred to as a "unit." A functional unit consists of all the components that are required for the unit to perform its function, whether these components are packaged in an individual drawer or in two drawers.

Faulty unit or function selection requires the use of logic similar to that employed by a medical doctor, auto mechanic, or other "technical doctor" when he searches for the cause of an illness or malfunction.

Assume that you are continually plagued with headache and you finally go to a doctor. If the doctor elaborates on the symptom by checking your eyes, ears, nose, and throat, taking your temperature, and listening to your heartbeat, but then promptly sends you to the operating room to have your foot amputated, you would certainly question his diagnosis. Instead of taking such an illogical step, the doctor will decide on the basis of his examination, whether the most probable trouble is poor eyesight, a sinus infection, or some other logical disorder. Only after making such a decision will the doctor prescribe a possible remedy.

Similarly, the technician who accomplishes the first two steps of our six-step procedure and then picks just any test or repair procedure in an attempt to correct the trouble is indeed a poor troubleshooter. He must first survey the information he has gathered; then, using his knowledge of equipment operation along with the aids provided in the applicable technical manuals, he must make a technically sound decision as to what is probably causing the recorded symptoms.

The abnormal performance indications you noted in steps 1 and 2 should also give you clues as to the probable location of an electronic malfunction. Electronic equipment can have as many as 10,000 circuits, or 70,000 individual parts. The probability of finding the faulty part by methodically checking each of the 70,000 parts in turn is highly remote. The size of the task can be reduced by a factor of seven by checking the outputs of each circuit rather than checking each part separately.

However, 10,000 tests is still a job of considerable magnitude. By dividing the 10,000 circuits into their normal groupings of electronic functional units–seven, a dozen, or two dozen–you can reduce the job to a practical number of tests. Whether the equipment contains thousands, hundreds, or just a few circuits, logical reasoning dictates that the troubleshooting problem can be resolved more quickly and accurately by reducing the total circuits into a small number of groups.

Assume that we've divided the 10,000 circuits into 12 functional units. Locating the faulty unit might require 12 output tests unless you were lucky enough to find it before all units were tested. This still represents a departure from our basic logic. Why should the doctor

amputate your foot if you had a sinus headache? Why should you test the turntable of a radio-television-phonograph console set if the picture on the TV tube is bad? You can predict that the trouble lies in the television receiver unit and confine your tests to that unit.

As explained previously, making faulty unit selections requires that you reach a decision as to the possible equipment area(s) which could probably produce the trouble symptom and associated information. At this point in our six-step procedure, the trouble area will be restricted to a functional unit of the equipment. Thus, the functional block diagram is indispensable at this point.

Assume that you have found no reception as the trouble symptom for the transceiver whose functional block diagram is illustrated in figure 9-13. Manipulation of the receiver volume and tuning controls has no effect upon the no reception condition. However, the power-on light and the dial lights of the receiver unit are all illuminated.

Out of the six functional units shown, only the power supply unit, the antenna assembly unit, and the receiver unit could possibly be at fault since these are the only units associated with signal reception. Figure 9-14 shows the thought process involved in formulating a valid faulty unit selection. The answers to the questions you must ask will be obtained from your knowledge of how the equipment operates and/or from your use of the technical diagrams in the technical manual. Most of them should come from a study of the functional block diagram.

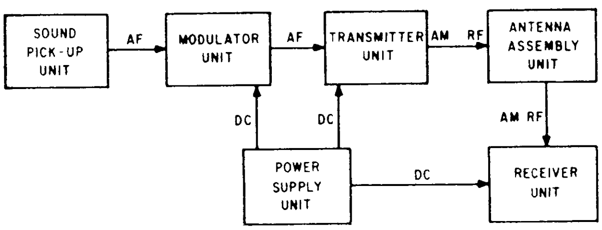

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Figure 9-13.—Functional Block of an AM Transceiver.

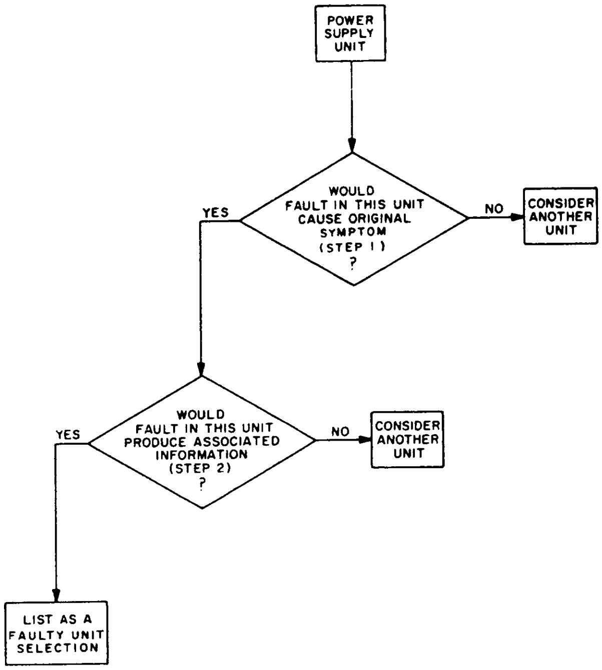

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Figure 9-14.—Considering Power Supply as a Faulty Unit Selection.

First we consider the power supply unit and ask ourselves, "Would a failure or abnormal performance on the part of the power supply cause the original trouble symptom?" If the answer is "no," we can go on to consider another unit. If the answer is "yes," (as it is for the symptom given above), we ask ourselves, "Would a failure or abnormal performance on the part of the power supply produce the associated information obtained during symptom elaboration?" For this example the answer would be "yes," because the fact that the dial lights and power-on light are illuminated does not prove that the proper operating voltages are being produced. This is true because these lights are in the filament voltage circuit only. Therefore, we list the power supply unit as a faulty unit selection, and we also note that the portion of this unit responsible for providing filament voltages is probably okay.

Next we consider the antenna assembly unit and receiver unit (separately) in the same manner. For the no-reception symptom and associated information given above, both of

these units must also be listed as faulty unit selections. A break in the antenna lead could easily cause our trouble. Similarly, many different faults in the receiver unit could be the cause of no reception.

The condition described above represents the maximum number of technically accurate selections–every functional unit associated with receiving an external signal may be at fault. The number of selections can be reduced if the second step–symptom elaboration–yields more information about the trouble symptom.

Now you should have a very good idea of how to go about making a faulty unit selection–the decision as to which equipment functional units are probably causing the trouble. These selections must, of course, be logical and must be technically substantiated by the information you obtained during symptom elaboration, the relationships between signal paths and functional units, and your operational knowledge of the equipment.

One of the reasons for performing this step is to save time. This is accomplished by making technically accurate selections of units which could contain the malfunction. Doing this eliminates the necessity of making illogical checks of all units. However, it must be understood that each unit so selected is only a probable source of the trouble even though its selection is based on technically valid evidence. The next step explains a time-saving and logical method of locating the unit that is most probably faulty.

Localizing the Faulty Function

The first three steps in our systematic approach to troubleshooting have dealt with the examination of "apparent" and "not so apparent" equipment performance deficiencies, as well as a logical selection of the probable faulty functional units. Up to this point no test equipment other than the controls and indicating devices physically built into the equipment has been utilized. No dust covers or equipment drawers have been removed to provide access to any of the parts or internal adjustments. After evaluating the symptom information, you have made mental decisions as to the most probable areas in which the malfunction could occur.

Localizing the faulty function means that you will have to determine which of the functional units of the multi-unit equipment is actually at fault. This is accomplished by systematically checking each faulty functional unit selection until the actual faulty unit is found. If none of the functional units in your list of selections display improper performance, it will be necessary for you to backtrack to step 3 and reevaluate the symptom information, as well as obtain more information if possible. In some cases it may be necessary to return to step 2 and obtain additional symptom-elaboration data.

At this point–step 4 in the troubleshooting sequence–you will bring into play your factual equipment knowledge and your skill in testing procedures. The utilization of standard or specialized test instruments and the interpretation of the test data will be very important throughout this and the remaining troubleshooting steps.

The simultaneous elimination of several functional units as the cause of the trouble symptom should be an important factor in deciding which faulty unit selection to test first. This requires an examination of the functional block diagram to see whether satisfactory test results from any one of the selections could also eliminate other units listed as probable causes.

Test point accessibility is also an important factor affecting the technician's logic in choosing a faulty functional unit selection for further examination. Actually, any point where wires join or where components are connected can serve as a test point.

Another factor to consider is past experience and history of repeated failures. Past experience with similar equipment and related trouble symptoms, as well as the probability of unit failure based upon records of repeated failures, should have some bearing upon the choice of a first test point. However, the selection should be based mainly upon a logical conclusion formed from data obtained in previous steps, without undue emphasis upon past experience and history of the equipment.

Now that you have mastered the process of choosing the first faulty functional unit selection to test, you might ask, "Where do I go from here?" The answer, of course, depends upon the results of your first step.

There can be only two results—a satisfactory indication or an unsatisfactory indication. The latter may be in the form of no indication or a degraded indication. In any event, the result obtained should lead you to the next logical test. At each point, a new bit of information enables you to narrow the trouble area until the faulty functional unit is located.

Localizing the Faulty Circuit

In step 5—localizing the faulty circuit—you will do rather extensive testing in order to isolate the trouble to a specific circuit within the faulty functional unit. To accomplish this, you will first be concerned with isolating a group of circuits within a functional unit, arranged according to a common electronic sub-function. Once the faulty circuit group has been located, you can perform the tests which will isolate the faulty circuit(s).

Before you continue the troubleshooting procedures into step 5, you should pause and assimilate all of the data obtained at this point which may aid you in performing the next step. After completing step 4, you know that all of the inputs to the faulty function are correct and that one or more of the outputs is incorrect or nonexistent. The incorrect output waveform(s) obtained in step 4 should be analyzed to obtain any information which may indicate possible trouble areas within the functional unit. It is important to remember that the original symptoms and clues obtained in the first two steps should not be discarded merely because steps 3 and 4 are completed. This information will be helpful throughout the troubleshooting procedure, and should be reviewed, together with all clues discovered in subsequent steps, before continuing to the next step.

Step 5 should be a continuation of the narrowing-down process. Each functional unit has a separate function within an equipment, and within each functional unit there may be two or more groups of circuits, each with a sub-function. This means that the input to each group (sub-function) is converted, and the output emerges in a different form. An understanding of the conversions which occur within a functional unit makes it possible to logically select possible trouble areas within the unit. Testing is then performed to isolate the defective circuit group. The same principles are applied to the circuit group to locate the faulty circuit within the group.

Another aid to troubleshooting is the "bracketing" process, which provides the technician with a physical means of narrowing down the trouble area to a faulty circuit group and then to a faulty circuit.

Once the tests in step 4—localizing the faulty function—have been performed and the faulty unit isolated, the bracketing process begins by placing brackets (either mentally or with a pencil) at the good input(s) and at the bad output(s) of the faulty function is the servicing block diagram. You know at this point that the trouble exists somewhere between the brackets. The idea is to make a test between the brackets and then move the brackets one at a time (either input or output bracket) and then make another test to determine whether the trouble is within the new bracketed area. This process continues until the brackets isolate the defective circuit.

The most important factor in bracketing is determining where the brackets should be moved in this narrowing-down process. This is determined on the basis of the technician's deductions from the analysis of systems and previous tests, the type of circuit paths through which the signal flows, and the accessibility of test points. All moves of the brackets should be aimed at isolating the trouble with a minimum number of tests.

Analyzing the Failure

The final step in our six-step troubleshooting procedure—failure analysis—will require that you test certain branches of the faulty circuit in order to determine where the faulty part lies. These branches are the interconnected networks associated with each element of the transistor,

electron tube, or other active device in the faulty circuit.

Step 6–failure analysis–places you in the position necessary to replace or repair faulty circuit components so that the equipment can be returned to optimum serviceability. However, locating the faulty part does not complete step 6. You will also be concerned with determining the cause of the failure. It is quite possible that still another failure occurred and, unless all faults are corrected, the trouble will reoccur at a later date. The final step in failure analysis requires that certain records be maintained. These records will aid you or some other technician in the future. They may also point out consistent failures which could be caused by a design error. When this step has been finished satisfactorily you can perform whatever repairs are necessary.

Once the faulty circuit has been isolated, the voltages and resistances of the various circuit branches must be measured, in order to determine which components within the circuit are at fault. The measurement results must be compared to voltage and resistance charts or tables in order to evaluate them. This information may appear on the apron of its associated fold-out schematic diagram, or it may be on a separate page(s) in the manual. The normal voltage and resistance reading to ground (or other point of significance) for each tube socket pin is given. Also listed are the conditions necessary to observe the gain reading, such as control settings and equipment connections.

Regardless of the type of trouble symptom, the actual fault can eventually be traced to one or more of the circuit parts–resistors, capacitors, etc–within the equipment.

By replacing the faulty part and rechecking equipment operation, you can return the equipment to operation with the knowledge that you have completed your troubleshooting duties.

SUMMARY OF SYSTEMS MAINTENANCE

The electronic systems found at a typical NSG activity are of a highly complex nature. Each portion of the system can be compared to a chain, being only as strong as the weakest link. Whereas the electronic system is useful only so long as all equipment within that system is operating correctly. Keeping this in mind, you as a technician must know the complete signal flow and operation of each system under your tasking. Thus, when there is a failure within the system, you should think in terms of the overall system prior to jumping feet first into an individual equipment that SEEMS to be malfunctioning. Make a few logical checks so that you will KNOW what equipment is at fault.

There is no substitute for a thorough working knowledge of the electronic system. This knowledge will prove invaluable in the performance of your duties.

SAFETY

The purpose of safety rules is to create within the individual an attitude of thinking and acting in terms of safety. Prescribed safety precautions are instrumental in avoiding preventable accidents and in maintaining a work environment which is conducive to good health. Operating procedures and work methods adopted with safety in mind do not expose personnel unnecessarily to injury or occupational health hazards.

Although responsibility for the safety of personnel is vested in the commanding officer, he frequently delegates his authority to subordinates to ensure that all prescribed safety precautions are understood and strictly enforced. Regardless of the manner in which authority may be delegated, safety is ultimately the responsibility of each individual.

As an individual, you have a responsibility to yourself and to your shipmates. You must always be alert to detect and report unsafe work practices and unsafe conditions so that they may be corrected before they cause accidents. Each individual must:

1. Report any unsafe condition, equipment, or material which he considers to be unsafe.

2. Warn others whom he believes to be endangered by known hazards or by failure to observe safety precautions.

3. Wear protective clothing or use protective equipment of the type approved for the safe performance of his work or duty.

4. Report to his supervisor any injury or evidence of impaired health occurring in the course of his work or duty.

5. In the event of an emergency or other unforeseen hazardous condition, each individual is expected to exercise reasonable caution as appropriate to the situation.

INSTALLED SAFETY DEVICES

Most electronic equipments utilizing high voltages have "built-in" devices which serve as safety features. As an example consider the conventional television receiver which is constructed in such a manner that it is necessary to disconnect the power cord from the chassis before removing the back panel. This serves as a simple but effective interlock switch. Safety devices such as interlocks, overload relays, and fuses should never be altered or disconnected except when making replacements. Safety or protective devices should never be changed or modified in any way without specific authorization. The interlock switch, which is ordinarily wired in series with the power-line leads to the power supply unit, is installed on the lid or door of the equipment case or enclosure in order to break the circuit when the lid or door is opened.

Fuses should be removed and replaced only after the circuit has been completely deenergized. A blown fuse is replaced with one of the same rated ampere capacity. You are permitted to replace a blown fuse with one of a higher rating only under emergency or battle conditions when continued use of the equipment is more important than consequences of possible damage to equipment. When possible, a circuit should be checked before a fuse is replaced, because a blown fuse usually indicates a circuit fault.

Never change a knife or cartridge-type fuse with your bare hands. Use an approved fuse puller (figure 9-15). These pullers are made either of laminated bakelite or fiber, and can handle a range of fuses up to 60 amperes. Grasp fuse firmly with puller (using end that best fits fuse size) and pull straight out from fuse cabinet.

Plug-type fuse holders are used extensively in modern electronic equipment. The fuses are removed easily and safely by unscrewing the insulated plug.

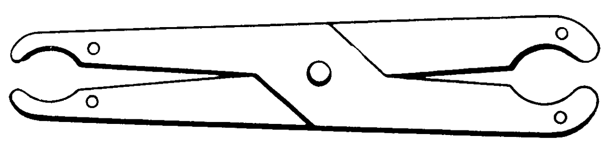
Unless work is being done on them, fuse boxes, junction boxes, lever-type boxes, and the like are kept closed.

TAGGING SWITCHES

When electronic equipment is being repaired or overhauled, make sure the main supply or cutout switches in each circuit from which power could possibly be fed are secured in the OPEN (or SAFETY) position and tagged. Switches should be secured by locking, if possible. The tag should read: "This circuit was ordered open and shall not be closed except by direct order of - - - -" (usually the person making, or in charge of, the repairs). After the work is complete, tags are removed by the same person. If more than one party is working, a tag for each working party is placed on the supply switch. Each party removes only its own tag as it completes its share of the work.

If switch-locking facilities are available, the switch should be locked in the OPEN (safety) position and the key retained by the person doing the work.

When circuits are grounded for protection of personnel engaged in installation or overhaul, such grounds should be located in the vicinity of the working party and should be secured



1.32A

Figure 9-15.—Fuse Puller.

properly to prevent accidental removal. If the grounding point is not near the working party, the tagging procedure just described should be followed, changing the wording on the tags.

WARNING SIGNS

Danger signs and suitable guards are provided to prevent personnel from coming in accidental contact with high voltages. The warning signs shown in figure 9-16 are posted on or near every radio transmitter, transmitting antenna lead-in trunks, and other electronic spaces throughout the station. The signs are painted red to make them more conspicuous. Additional signs warn against such hazards as explosive vapors and effects of stack gases aloft. Look for warning signs and obey them. Notify your supervisor if a dangerous condition exists for which no warning sign is posted.

HIGH-VOLTAGE PRECAUTIONS

No one should work alone on energized equipment. Tools and equipment containing metal parts should not be used in an area where any exposed electric wiring exists. Do not work on any type of electrical apparatus with wet hands or while wearing wet clothing, and do not wear loose or flapping clothing. Before working on electronic or electrical equipment, remove all rings, wristwatches, bracelets, badges suspended from chains, and similar metal items. Check clothing to be certain that it does not contain exposed zippers, metal buttons, or any type of metal fasteners.

SHORTING/GROUNDING BAR

The shorting/grounding bar shown in figure 9-17 provides a safe method for grounding deenergized circuits. The flexible lead is connected to a grounded part of the cabinet or chassis by means of the alligator clip. This ground connection is always made first. Then holding only the insulated handle, the copper probe is touched to the circuit or part to be discharged to ground. This discharging operation should be repeated several times.

Before touching a capacitor that is connected to a deenergized circuit, or one that is disconnected entirely, short-circuit the terminals with the shorting bar. This operation should be repeated several times to make sure the capacitor is fully discharged.

RUBBER MATTING

Aboard ship a gray, fire retardant, rubber matting with a diamond-shaped surface is cemented to the deck in all electronic spaces. Rubber matting insulates the operator from the steel deck, and the diamond-shaped surface pattern is easy to keep clean and provides safe, nonskid footing. At shore stations, rubber matting is installed around electronic equipment to protect personnel who service or tune the equipment. Usually the matting does not cover the entire deck area.

To ensure that the safety factors that were incorporated in the manufacture of the material are effective, and the matting is completely safe for use, operation and maintenance personnel must make certain that all foreign substances that could possibly contaminate or impair the dielectric properties of the matting material are promptly removed from its surface areas. For this reason, the matting must be periodically inspected and cleaned. When inspecting the matting, personnel should make certain the dielectric properties of the matting have not been impaired by oil impregnation, piercing by metal chips, cracking, or other defects. Matting which is defective for any reason should be replaced.

ACCIDENTAL GROUNDS AND SHORT CIRCUITS

Continual inspection with awareness of the danger of accidental grounds and short circuits is necessary for the safety of personnel. Any dangerous conditions shall be reported and should be corrected by qualified personnel if possible before any further work is done in the area. Most electrical shocks are caused by using improperly grounded tools and other equipment (e.g. portable drills, coffee pots, movie projectors). Each time teletypewriter equipment

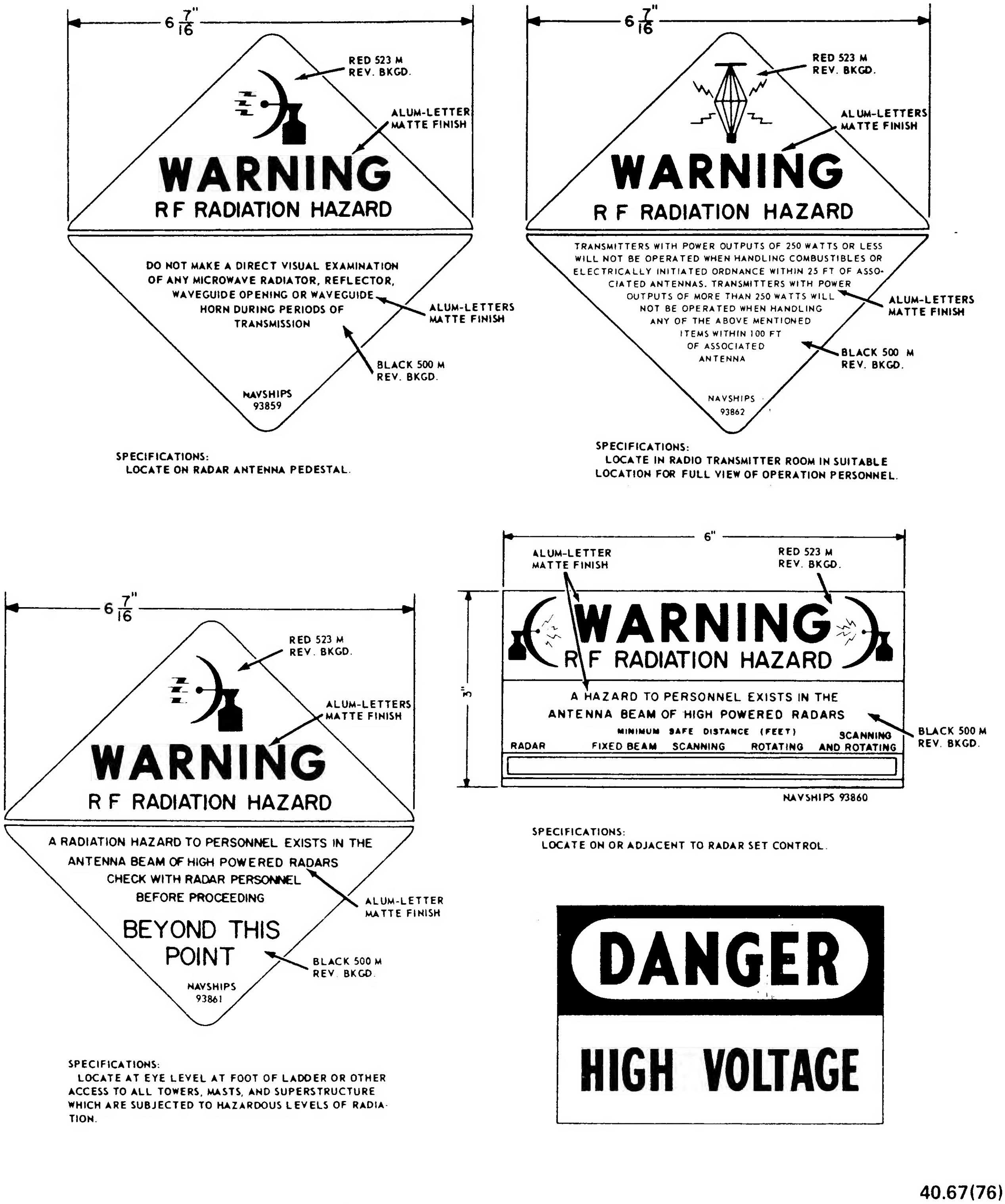


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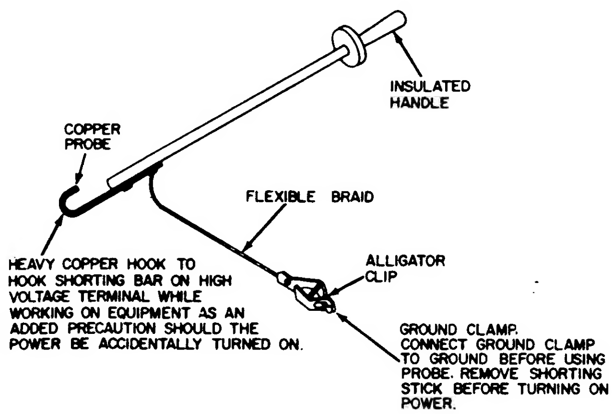
Figure 9-16.—Hazard Warning Signs.



1.1(76)

Figure 9-17.—Shorting/Grounding Bar.

is opened up for cleaning, tape or paper change, etc., care should be taken to ensure that wires and insulation are not damaged, thus allowing for a possible accidental ground or short circuit.

USE OF SOLVENTS

The use of solvents as cleaning agents on electronic and electro-mechanical equipments is a common practice. Under certain conditions all organic solvents are toxic in nature and, with the exception of chlorinated solvents, they are flammable. The most commonly used type of solvents are the halogenated hydrocarbons. Included in this group are carbon tetrachloride, methyl chloroform (1,1,1-trichloroethane), trichloroethane, and perchloroethlene. However, not all are used. Carbon tetrachloride has been prohibited from use by the Chief of Naval Operations due to its toxic nature. Methyl chloroform (1,1,1-trichloroethane) and trichloroethane are approved for use as degreasing agents.

The following precautions apply when using solvents:

1. Benzene, gasoline, and similar flammable liquids should never be used as cleaning agents, either on energized or deenergized apparatus.
2. NEVER use carbon tetrachloride as a cleaning solvent. Although not a possible source of fire, it is hazardous because of the dangerous effects of breathing its vapors. Use of carbon tetrachloride may result in headache, dizziness, nausea, loss of consciousness, or even death.
3. ALWAYS use solvents in a well ventilated area.
4. NEVER use volatile liquids (turpentine, paint thinner, etc.) near energized electronic or electrical equipment.

RADIOACTIVE ELECTRON TUBES

Poisoning from radioactive materials contained in electron tubes such as radiac, spark gap, TR, glow lamp, and cold cathode tubes may be of 3 types:

1. ASSIMILATION—Eating, drinking, or breathing radium or radium compounds or absorbing them through cuts. Radium-bearing dust, which may be present in certain tubes, is dangerous in this respect.
2. BREATHING RADON—Radon is a tasteless, odorless, colorless gas that is given off by radium and radium compounds at all times. When breathed into the lungs it may cause severe injury.
3. RADIATION—Radium and radium compounds give off harmful, invisible radiations that can cause dangerous burns.

So long as these electron tubes remain intact and are not broken, no great hazard exists. However, if these tubes are broken and the radioactive material is exposed, or escapes from the confines of the electron tube, the radioactive material becomes a potential hazard.

The following precautions should be taken to ensure proper handling of radioactive electron tubes and safety of personnel:

1. Radioactive tubes should not be removed from cartons until immediately prior to actual installation.
2. When a tube containing a radioactive material is removed from equipment, it should be placed in an appropriate carton to prevent possible breakage.

3. A radioactive tube should never be carried in ones pocket, or elsewhere on a person in such a manner that breakage can occur.

4. If breakage does occur during handling or removing of a radioactive electron tube, notify the cognizant authority and obtain the services of qualified radiological personnel immediately.

5. Isolate the immediate area of exposure to protect other personnel from possible contamination and exposure.

6. Follow the established procedures set forth in NavMed P-5055.

7. Do not permit contaminated material to come in contact with any part of a person's body.

8. Take care to avoid breathing any vapor or dust which may be released by tube breakage.

9. Wear rubber or plastic gloves at all times during cleanup and decontamination procedures.

10. Use forceps for the removal of large fragments of a broken radioactive tube. The remaining small particles can be removed with a vacuum cleaner, using an approved disposal collection bag. If a vacuum cleaner is not available, use a wet cloth to wipe the affected area. In this case, be sure to make one stroke at a time. DO NOT use a back-and-forth motion. After each stroke, fold the cloth in half, always holding one clean side and using the other for the new stroke. Dispose of the cloth in the manner stated later.

11. No food or drink should be brought into the contaminated area or near any radioactive material.

12. Immediately after leaving a contaminated area, personnel who have handled radioactive material in any way should remove any clothing found to be contaminated. They should also thoroughly wash their hands and arms with soap and water, and rinse with clean water.

13. Immediately notify a medical officer if a wound is sustained from a sharp radioactive object. If a medical officer cannot reach the scene immediately, mild bleeding should be stimulated by pressure about the wound and the use of suction bulbs. DO NOT USE THE MOUTH, if the wound is of the puncture type, or the opening is small, make an incision to promote free bleeding, and to facilitate cleaning and flushing of the wound.

14. When cleaning a contaminated area, seal all debris, cleaning cloths, and collection bags in a container such as a plastic bag, heavy wax paper, or glass jar, and place in a steel can until disposed of in accordance with existing instruction. Decontaminate all tools and implements used to remove a radioactive substance, using soap and water. Monitor the tools and implements for radiation with an authorized radiac set; they should emit less than 0.1 MR/HR at the surface.

CATHODE-RAY TUBES (CRTs)

Cathode-ray tubes should always be handled with extreme caution. The glass envelope encloses a high vacuum and, because of its large surface area, is subject to considerable force caused by atmospheric pressure. (The total force on the surface of a 10-inch CRT is 3750 pounds, or nearly two tons; over 1000 pounds is exerted on its face alone.) Proper handling and disposal instructions for CRTs are as follows:

1. Avoid scratching or striking the surface.
2. Do not use excessive force when removing or replacing the CRT in its deflection yoke or its socket.
3. Do not try to remove an electromagnetic type CRT from its yoke until the high voltage has been discharged from its anode connector (hole).
4. Never hold the CRT by its neck.
5. Always set a CRT with its face down on a thick piece of felt, rubber, or smooth cloth.
6. Always handle the CRT gently. Rough handling or a sharp blow on the service bench can displace the electrodes within the tube, causing faulty operation.
7. Safety glasses and gloves should be worn when handling CRTs.
8. Before a CRT is discarded, it should be made harmless by breaking the vacuum glass seal. To accomplish this, proceed as follows:

- Place the tube that is to be discarded in an empty carton, with its face down and protection over its sides and back.

Carefully break off the locating pin from its base (figure 9-18) to remove the vacuum. If this does not break the vacuum use the alternate method below.

WARNING

The chemical phosphor coating of the CRT face is extremely toxic. When disposing of a broken tube, be careful not to come into contact with this compound.

An alternate method of rendering a CRT harmless is to place it in a carton. Then, using a long, thin rod, pierce through the carton and the side of the CRT.

BATTERIES

When working with batteries, precautions must be taken against shock and accidental shorting of the terminals, and against the possibility of injury resulting from contact with electrolyte. The standard safety measures which apply in most cases include the following:

TOOLS. Use tools with insulated handles when removing or replacing batteries.

INSTALLATION. When replacing a battery which has one terminal grounded, remove the grounded terminal first and do not reconnect it until the new battery is in place and the other connections have been made.

ACID ELECTROLYTE. When preparing or handling solutions of sulfuric acid for use in lead-acid cells, observe the following precautions:

1. NEVER POUR WATER INTO ACID. The acid must be poured slowly into the water to prevent a sudden and violent reaction.
2. Guard the eyes and skin from splashing acid.

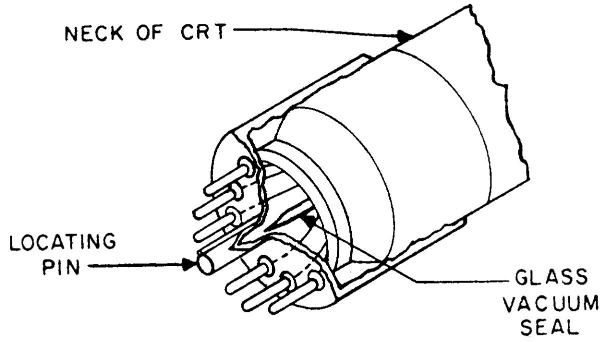


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Figure 9-18.—Cathode-Ray Tube Base Structure.

3. Do not store sulfuric acid in places where freezing temperatures are possible.
4. Keep the electrolyte in the cells at a level just above the separators.

ALKALINE ELECTROLYTE. Battery cells containing corrosive alkaline solutions are often used. Examples are silver-zinc and nickel-cadmium batteries. In both of these the electrolyte is a solution of potassium hydroxide. This solution is chemically active and extreme care should be taken to avoid spilling or splashing it on the skin, on clothing or on surrounding equipment. If this occurs, the affected areas should be flushed immediately with large quantities of water. Afterwards, the chemical can be neutralized with a 10% solution of acetic acid if this is available.

Preparation of electrolyte should be done only by experienced personnel, all mixing being done in heat-resistant, plastic jars. Every precaution should be taken to prevent high temperatures from developing in the solution. The mixture should be stirred constantly with a Monel metal paddle and should be stored in hermetically sealed, plastic containers. These should not be opened until the electrolyte is needed for filling the cells.